SANDIA LABNEWS
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# Using a mineral 'sponge' to catch uranium


**ROCKY MOUNTAIN HIGH** — Mark Rigali, a Sandia geochemist, left front, presents the apatite remediation technology to legacy management stakeholders during a demonstration at the former uranium mill near Rifle, Colorado, in 2019. Ken Williams, the Lawrence Berkeley environmental remediation program lead, stands right behind him and observes.

**Photo courtesy of Tashina Jasso, DOE Legacy Management**

## *Remediation technology reduces uranium levels 10,000-fold at legacy site in Colorado*

*By* ***Mollie Rappe***

A team of researchers from Sandia, Lawrence Berkeley and Pacific Northwest national laboratories tested a "spongelike" mineral that can "soak up" uranium at a former uranium mill near Rifle, Colorado.

The researchers found that the mineral, calcium apatite, soaks up and binds uranium from the groundwater, reducing it by more than ten-thousandfold.

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**SUPER FLOWER BLOOD MOON ECLIPSE** — The supermoon eclipse took place May 26. **Photo by Randy Montoya**

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## LABNEWS Notes

**EDITOR'S NOTE:** We've stopped printing the *Lab News*, but will continue to publish every two weeks. We want you to remain in our community of readers, so please send your comments and suggestions for stories or for improving the paper. *Lab News* welcomes guest columnists who wish to tell their own "Sandia story" or offer their observations on life at the Labs or on science and technology in the news. If you have a column (500-800 words) or an idea to submit, contact *Lab News* editor Jim Danneskiold at jddanne@sandia.gov.

## LABNEWS Notes

# We are not going back. *We are moving forward.*

*Strategies to help us adapt to the next step of our collective pandemic journey*

*By* **Tamara Cagney**
*Employee Assistance Program counselor*

**CALIFORNIA COUNSELOR** — Tamara Cagney is a counselor with the Employee Assistance Program at Sandia/California.

**Photo courtesy of Tamara Cagney**

As the number of COVID-19 vaccinations increases, the threat of the disease is decreasing in the United States, ushering us into the next step of our pandemic journey. Even though some safety precautions will still be required, Sandia leaders are looking ahead to this next phase — leveraging technology, rethinking workspaces, redefining workflows and exploring potential hybrid work models. Efforts are being made to expand long-term flexible work options and optimize limited space.

We are certainly not going back to "normal" or even to a pre-COVID-19 world. Instead, we are entering an unexplored space where everyone must adapt since the past and present are no longer good predictors of the future. Keeping an open mind and being willing to learn with agility will be key so that we can assess what's relevant, ignore what isn't, quickly absorb and apply new concepts, evaluate results, bring lessons from the last year forward, experiment and pivot to seize new opportunities.

### A sudden transition to a new work environment

Think back to March 2020. With zero planning and no warning, most of us switched to working remotely in just a few weeks! As one of my clients said, "If we had been told that at some point in the future we would have to work

remotely, Sandia would still be running our pilot a year later." We did in two weeks what people have been trying to do for years.

The transition from having almost everyone on-site to having a majority of remote workers was not easy. Challenges included finding the right technology, communicating with colleagues and customers and helping our geographically distributed teams still feel like teams.

By working through these challenges, we have learned to function at an even higher level and realized that we can remain tightly connected to our work, teams and mission — even from a distance. This unprecedented period unleashed people's talents, creativity and passions in a way that simply isn't possible under "normal" conditions.

## Lessons learned with applications for the future

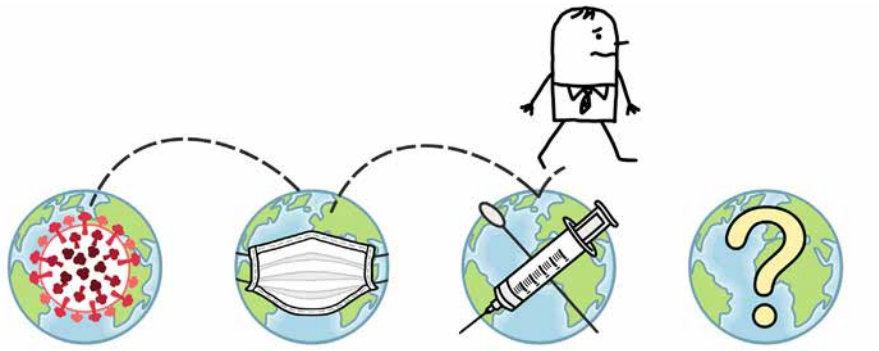
All of us were faced with an "impossible" demand, and together we made it happen. And we learned. Some of these lessons can be applied to our new work approach — redefining how, where, when and by whom work gets done going forward.

**We now know the following is possible:**

- Staying connected as a team even if not physically in the same place.
- Being productive while working remotely.
- Meeting deliverables and milestones while managing flexible workspaces and schedules.
- Managing our work time at home and developing new work rhythm.

**We noted what helped during remote working:**

- A strong virtual onboarding process for new staff.
- Shorter meetings with clear agendas to reduce virtual meeting fatigue.
- Frequent town hall meetings to help us stay informed.
- Manager check-ins and virtual office hours.
- Frequent informal feedback and coaching.



**LOOKING FORWARD** — Imagining the future of work beyond the COVID-19 pandemic.
**Graphic credit of Getty Images**

**We learned lessons about our work styles and how to better manage our workdays:**

- Most of us do not miss our commute, although some of us miss the thinking and decompression time afforded by our prior commutes.

  TIP: *Take a walk at the end of your workday to think and decompress.*

- Blurred boundaries between work and home can make us feel like we are living at work rather than working at home.

  TIP: *Create firm boundaries and take time for self-care.*

- Days dominated by back-to-back meetings mean that processing and working on tasks happens after the working day.

  TIP: *Protect blocks of thinking and working time in your office calendar.*

## Different perspectives on the next phase

Remote work has been a boon for some people, giving them more time with family and more freedom and flexibility over their schedules, plus the comforts of home. But for others, remote work has also been burdensome — with distractions from kids, partners and roommates, makeshift workspaces and little to no divide between work and home life.

Some Sandians have been mostly on-site this past year and have become accustomed to the space, the quiet and the critters. They will definitely feel the shift as more people return to offices, vaults and labs.

We are as different in how we see the next reentry phase at Sandia as we are in everything else. Some of us are ready to end working from home and get on-site. More are hoping for a hybrid schedule that allows them to continue remote work part of the time. Most of us will go back to the office at least some of the time. And we have learned that many of us are hungry for the connection, camaraderie and innovation that come from gathering in person.

But some are panicking about the inevitable return to their old pre-pandemic office work routine. On-site reentry anxiety is real. Reentry anxiety is a combination of the overwhelming thought of reacclimating to an office environment we have not seen in more than a year and the fact that — despite vaccines — the COVID-19 pandemic is not over yet.

## Questions without definitive answers

For now, most of our thinking about the next phase — reentry and reintegration to work on-site — revolves around questions rather than definitive answers:

- What will work look like in the coming months?
- When might I need to go to the office?
- Will I have the same workspace?
- Will I have to share my space?
- What expectations will my manager have of me?
- What flexibility might exist?

These are all fair questions to be asking, and everyone is grappling with the need to create clear expectations about what work will look like as we build Sandia's future.

# Navigating this tumultuous time

If you are feeling uneasy or anxious about what the future holds, you have lots of company. Here are a few things to consider to help you navigate this tumultuous time:

1. **Be patient with yourself and others.** This is a new and unique situation that everyone is going through. Despite our best efforts, mistakes and adjustments will be made. Give yourself space to be patient and understanding with yourself and others as we all work to find our way to our future world of work at Sandia.
2. **Be prepared.** Understanding yourself, your needs and your "signals" will help you to be attuned to how you are reacting. The situation will, no doubt, continue to evolve, but you can find some comfort in focusing on being in control of what you can influence.
3. **Talk to your coworkers and manager.** You're not going through this by yourself, and the questions you have are shared by others. Find ways to engage others in dialogue about the realities of the situation: what is known, what is not and the path forward. If you're comfortable with being vulnerable, find ways to share your emotions and fears associated with the future. Let people know what you need so they can help.
4. **If you are in a leadership position, overcommunicate.** Anxious team members are going to fill any silence with noise, and oftentimes the stories we tell ourselves may not be grounded in fact and reality. Don't let open space fill with anxiety. Make extra time and effort to communicate early and often. It may feel like you're overdoing it, but you're not. People want to be a part of the process and feel in the know, so look for ways to actively include them in figuring out a path that works for the group and the diverse people on the team.
5. When the anxiety of the unknown begins to swell, sometimes the best first step is **simply to stop for a beat and breathe.** There are plenty of fantastic resources out there to help guide you in learning how to take a pause, breathe and recenter yourself. Check out the resources offered by Preventive Health (in CA, call 925-294-3500; in NM, call 505-284-4700, Option 1).
6. **Get help.** If you find that the anxiety associated with these changes is becoming too much to manage, be honest with yourself, and acknowledge that it may be time to reach out to Sandia's Employee Assistance Program (in CA, call Sharon Johnson at 925-294-6433; in NM, call 505-844-4237, Option 1).

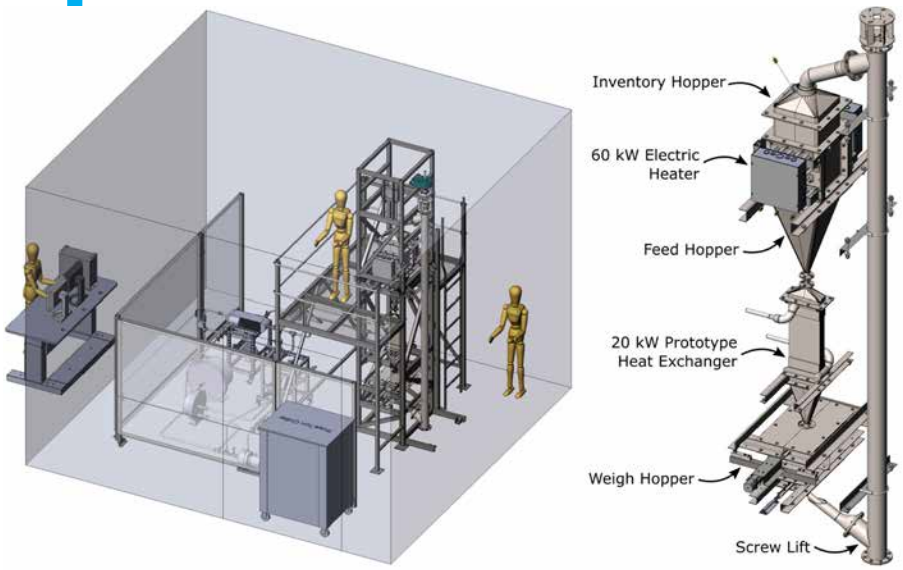
One of the key obstacles is the fact that no one really knows the answers to these questions right now. Even the most intentional leaders are trying to create some level of clarity for us while many of the variables are still quite dynamic. We are facing a whole new wave of making decisions without adequate data. This lack of clear answers weighs on people, some more than others.

Sandia's goal is to develop a culture that is equally supportive of remote and on-site workforce members. The new and developing realities will evolve, but regardless of the difficulties, we all have an opportunity to create an even better workplace — one that allows us to be more connected to one another, find more balance between work and home and advance equality — ultimately leading to increased innovation, creativity, job satisfaction and better business outcomes.

# Testing heat exchangers helps move solar plans forward

**EXCEEDING CURRENT LIMITS** — The heat exchanger manufactured at Vacuum Processing Engineering.

**Photo by Dereje Shiferaw, Vacuum Processing Engineering**




**STEADY AS SHE FLOWS** — An illustration of the test facility, where particle and sCO2 flows can circulate indefinitely and achieve true steady-state operating conditions by maintaining accurate control over the heat exchanger inlet temperatures.

**Graphic by Kevin Albrecht**

*By* **Kelly Sullivan**

Sandia researchers have completed a two-year effort to evaluate heat exchanger performance for the Labs' latest concentrating solar power project.

The DOE's Solar Energy Technologies Office funded the $450,000 project to develop a small-scale test facility for particle-to-supercritical carbon dioxide, or $sCO_2$, heat exchangers by creating flow loops for $sCO_2$ and heated particles, and build a novel heat-exchanger that met performance requirements for Sandia's larger role building and testing the $25 million DOE Generation 3 Particle Pilot Plant.

"This was a critical de-risking step to evaluate the performance and model predictions for the heat exchanger that allows us to then construct a much larger, one megawatt heat exchanger for the G3P3 project," said Kevin Albrecht, project lead in the Labs' concentrating solar power program.

The new particle flow loop can deliver up to 60 kilowatts of heat at 600 degrees C and a flow rate of 0.4 kilograms per second. The loop was developed to enable long-duration, off-sun testing of small prototype heat exchangers to produce model validation data at steady-state operating conditions.

## Steady-state flows

By building the test facility, the team sought to alleviate common issues with heat exchangers. Their goal was to have the particle and $sCO_2$ flows circulate indefinitely and achieve true steady-state operating conditions by maintaining accurate temperature control for the heat exchanger inlet.

Kevin said a real-world system would use solar energy to heat the particles and $sCO_2$ to spin a turbine producing electrical energy, but for the project, the scientists designed a facility using electrical energy to heat particles passing through the two loops.

The Sandia team worked with companies it had worked with before — SOLEX Thermal Science and Vacuum Process Engineering — to come up with a design. They then measured the performance to be four to six times higher than any other known particle-to-$sCO_2$ heat exchanger, Kevin said.

"Sandia and VPE have been working together for many years on the development of $sCO_2$ heat exchangers for heat recuperation," Kevin said, "and Sandia, VPE and Solex have been collaboratively developing primary power cycle heat exchangers for particle concentrating solar power since 2015."

## Development, testing continue

After the project concluded earlier this year, Kevin said the team received follow-on funding for continued development of the facility.

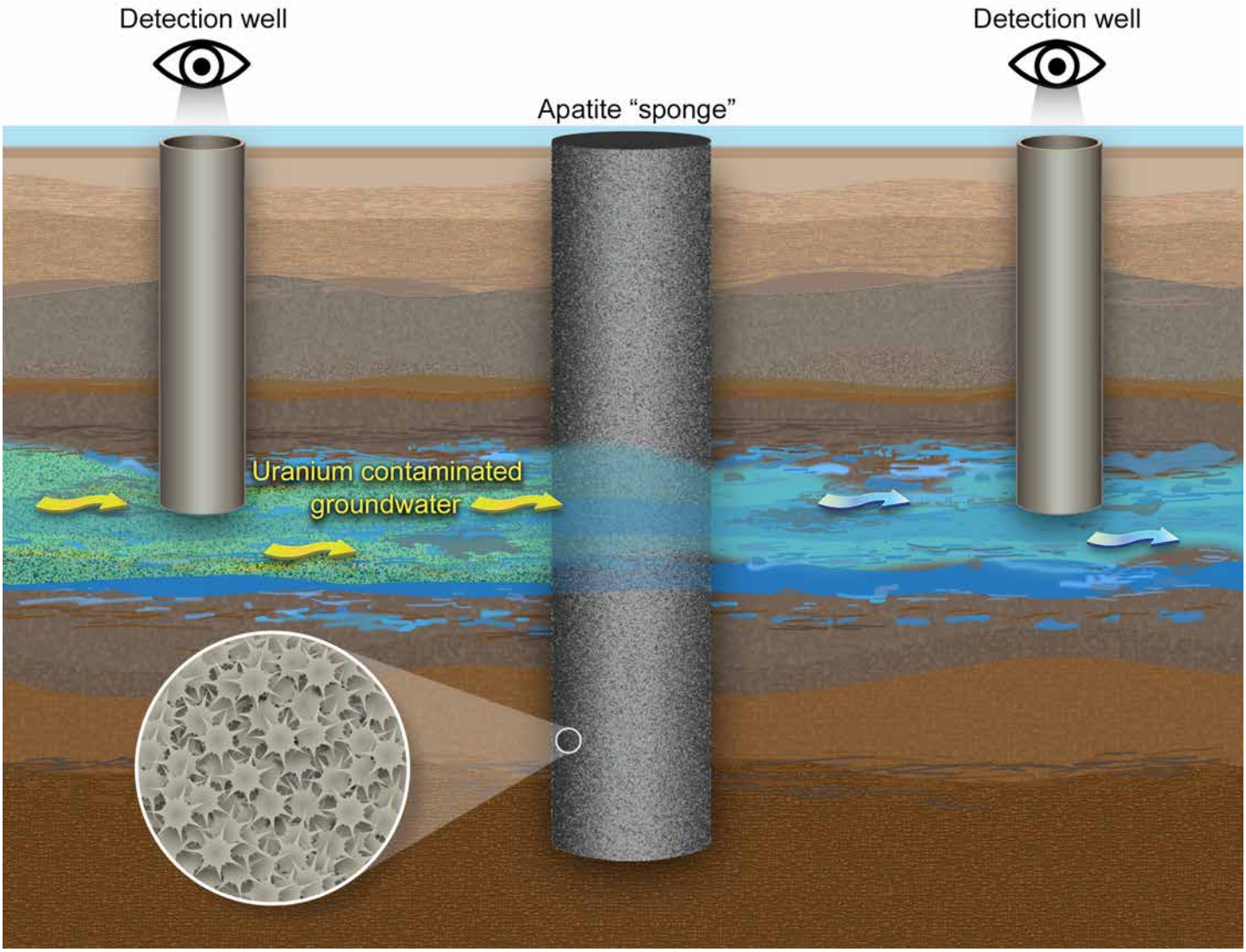
The researchers also will provide testing for outside customers. Heat exchanger vendors and universities that have novel concepts for heat exchangers will be able to bring their ideas to Sandia for assessment.

For now, the team will continue to develop a higher-temperature version of the heat exchanger and scale their current model for use in the broader Gen 3 CSP project.

"It is great to see this work moving forward, as well as the external interest in the project with some promising paths to commercialization," Kevin said.

Members of the Sandia team included: Hendrik Frederik Laubscher, Christopher Paul Bowen, Cliff Ho, Robert Crandell, Roger Dean Buck, Daniel A. Ray, Lam Banh and former employee Matthew Carlson.

More information is available about Sandia's Development and Testing of a 20 kW Moving Packed-Bed Particle-to-$sCO_2$ Heat Exchanger and Test Facility, Concentrating Solar Power program and the Generation 3 CSP Systems (Gen 3 CSP) program.




**SOAKING UP U** — A graphical illustration of how the test of the apatite mineral's ability to absorb uranium was conducted by Sandia, Lawrence Berkeley and Pacific Northwest national laboratories researchers. The researchers found that the water downstream of the apatite "sponge" had 10,000 times less uranium than the water upstream of the sponge.

**Graphic by Dan Thompson**

## Apatite uranium

CONTINUED FROM PAGE 1

"The apatite technology has successfully reduced the concentration of uranium, vanadium and molybdenum in the groundwater at the Rifle site," said Mark Rigali, the Sandia geochemist leading the project. "Moreover, the levels of uranium have remained below the Department of Energy's target concentration for more than three years."

The contaminated mill site near Rifle is about 180 miles west of Denver. Since 2002, DOE's Office of Legacy Management has used the site to test a variety of different uranium-remediation technologies.

All forms of uranium are radioactive and are toxic when ingested. Molybdenum and vanadium, on the other hand, are beneficial at very, very low levels, but are toxic at high concentrations. While the Rifle test site is remote, there are thousands of sites around the world that are similarly contaminated with radioactive elements and heavy metals that threaten groundwater, surface water and food supplies.

Calcium apatite is a mineral commonly used in fertilizer and is also a major component of bones and teeth. The researchers formed a "sponge" in the ground by injecting two inexpensive and nontoxic chemicals, calcium citrate and sodium phosphate, into a well especially designed for injecting solutions underground at the former uranium mill.

Once in the ground, helpful soil bacteria ate the calcium citrate and excreted calcium in a form that allows it to rapidly react with the sodium phosphate to form calcium apatite, which coated sand and soil particles underground to form the sponge. The apatite sponge captures contaminants, such as uranium, as it forms on the soil particles around the injection well, and afterward as the groundwater flows through the rough sponge. Once formed, the apatite is incredibly stable and can hold onto captured contaminants for millennia.

### Soaking up half of the periodic table

"The apatite-based approach for uranium remediation has been by far the most effective and long-lasting without

any significant negative side effects," said Ken Williams, **environmental remediation and water resources program lead** at Lawrence Berkeley. "It's basically been a win-win-win situation. The first win is the ease of operation with only one injection needed. The next win is uranium being removed to incredibly low levels. The third win is the lack of significant deleterious consequences."

Williams has been testing different uranium remediation techniques at the Rifle site for more than a decade, since he was a graduate student. As a student, he was involved in a project at the site where they fed soil bacteria vinegar to remediate uranium that had some unfortunate side effects.

The apatite remediation technology was invented by former Sandia chemical engineer Robert Moore. It has been used at DOE's **Hanford Site** in southeastern Washington state to protect the Columbia River from strontium-90, another radioactive isotope, and at the Fukushima Dai-ichi nuclear plant.

Geologists know that apatite can capture elements from more than half of the periodic table of elements, Mark said, but the team conducted initial laboratory-based tests to confirm apatite would bind dissolved uranium. These tests were conducted by Jim Szecsody, a geochemist at Pacific Northwest National Laboratory.

In addition to reducing the amount of uranium in groundwater more than ten-thousandfold, Mark and Williams found that the apatite reduced the amount of vanadium by more than a hundredfold. Vanadium is another contaminant left over from uranium milling, along with molybdenum, selenium and arsenic. Auspiciously, the apatite-based remediation technology captures these other toxic chemicals too, they said.

## The future of apatite remediation

Computer modeling by Sandia geoscientist Pat Brady suggests that the uranium will remain contained within the apatite mineral for tens of thousands of years — possibly longer than the mill site flood plain will remain in its current location adjacent to the Colorado River, Mark said.

Williams will continue measuring the amount of contaminants in the groundwater downstream of the apatite sponge every month until the sponge is "full." This will allow the research team to learn how much uranium and other contaminants the apatite can hold and when the sponge would need to be "refreshed" with more apatite, he said.

The apatite technology is being considered for use at several other contaminated locations, both federally managed and privately owned, said Mark. Also increasing the potential applicability of apatite remediation is the fact that it can be "tuned" to capture different contaminants of concern including lead and arsenic.

"The apatite family of minerals is very large," he added. "And they all have varying abilities to capture and store contaminants. You can literally tune the structure of apatite to go after specific contaminants of concern."

Copper apatite, for example, is a great sponge for arsenic.

"This has been one of the most rewarding projects that I've gotten to work on at Sandia," Mark said. "It's great to have these types of opportunities because you feel like you're doing something that is solving a problem and making a difference. I know this technology could be used at dozens of sites for uranium remediation."

The test in Rifle was funded by DOE's Office of Legacy Management, while the development of original apatite remediation technology was supported by Sandia's **Laboratory Directed Research and Development** program.

# Cleared for takeoff

## *Airline safety center departs after 30 years*

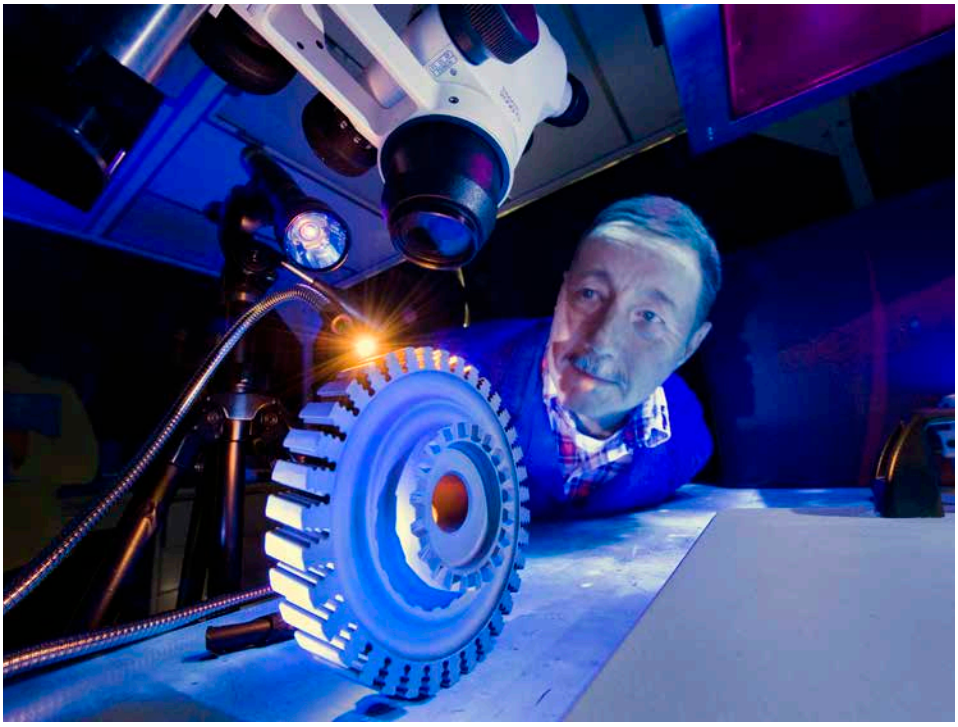
**BEHIND THE PANELS** — At the hangar dedication in 1993, Dennis Roach, second from left, pointed out features of a Boeing 737 to, from left, Bruce Singer, then-Deputy Service Director of the Federal Aviation Administration Technical Center, then-Sandia president Al Narath, then-Albuquerque Mayor Louis Saavedra, then-Rep. Steve Schiff and then-Sen. Pete Domenici.

*Story by* **Kristen Meub**
*Photos by* **Randy Montoya**

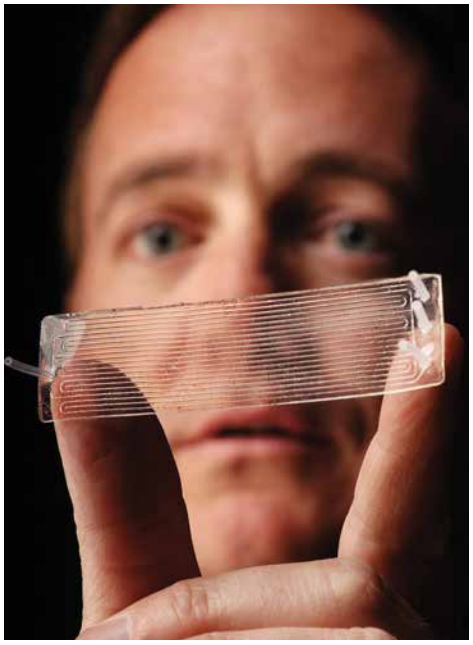
A 30-year program that made flying safer through continued innovations in airplane inspection, maintenance and airworthiness research has ended its tenure at Sandia.

The Federal Aviation Administration Airworthiness Assurance Center, or AANC, operated by Sandia for the FAA, is moving to the National Institute of Aviation Research at Wichita State University to combine with another long-standing FAA center. The planned move supports shifts in structure at both Sandia and the FAA.

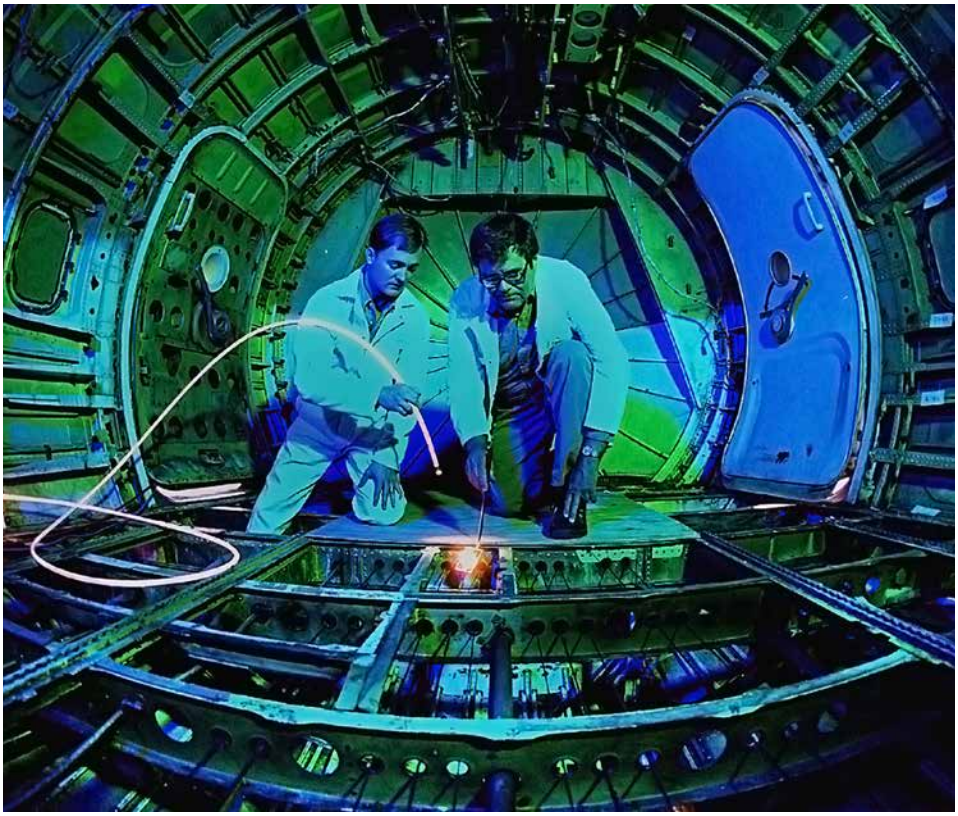
At the AANC, Sandia researchers partnered with staff from aircraft manufacturers, airlines, regulatory agencies, universities and industry to develop inspection and maintenance systems for airplanes. The



**SEEKING SMALL CRACKS IN ENGINE COMPONENTS** — Mike Bode uses high-fidelity optics and phased array eddy current methods to inspect the hub of an engine blade for cracks in the dovetail assembly.



**EMBEDDED CRACK DETECTION** — Dennis Roach with a Comparative Vacuum Monitoring device showing galleries etched into the sensor's underside. The sensors can be mounted on aircraft structures wherever a flaw may be expected to form.



**LOOKING FOR FATIGUE** — Dennis Roach and Ken Harmon examine the inside of a Boeing 707 for long-term structural fatigue. Nondestructive techniques allow inspectors to assess the integrity of aircraft structures without disassembly.

**STRUCTURAL HEALTH MONITORING** — Senior Scientist Dennis Roach, center, works inside the cabin of a B737 test bed, installing and acquiring data from Structural Health Monitoring sensors with Sandia mechanical engineers Stephen Neidigk, left, and Tom Rice.

original focus was on developing nondestructive inspection techniques for aging airplanes and then grew to include airworthiness assurance needs throughout the lifetime of all aircraft systems.

"Our goal was to develop the technology, prove the technology and, just as importantly, transfer the technology to industry to so it could be used routinely to ensure flight safety," said Dennis Roach, Senior Scientist and Sandia's lead engineer at the center. "The AANC at Sandia became a trusted source of unbiased technology development and validation for an array of programs."

The center supported a wide range of airplane safety and reliability and new technology application concerns, including operations, structural repair, advanced materials, corrosion monitoring and control, human factors, engine and fuel systems, landing gear, mechanical and electrical systems, structural modeling and analysis, sensor and instrument development, crashworthiness, aircraft certification, information processing and analysis, accident investigation, regulatory and advisory oversight requirements, failure analysis and systems safety.

The center also collaborated with other industries and all branches of the military on multiple engineering system and reliability needs.

Dennis says the center staff adapted to and created many changes in the aviation industry. For example, the sole focus on metallic structures shifted into research in composite structures as the next generation of aircraft used these materials as their primary structure. Similarly, hand-deployed nondestructive inspection methods gave way to automated Structural Health Monitoring as the center led the way to the introduction of on-board sensors and use of smart structures to improve damage detection on aircraft.

## Spin-offs, investigations and innovation

Some projects of note, including spin-off programs for other industries, include:

Accident investigations: The center supported accident investigations for TWA800, Swiss Air111, American Airline587 and several rotorcraft accidents.

All programs resulted in the introduction of enhanced inspections methods for critical components.

Space shuttle program: After the Space shuttle Columbia accident, the center worked on NASA's Return to Flight program to develop an inspection system to certify each Space shuttle before launch.

Syncrude/Exxon oil exploration: Composite expertise gained from aviation programs was used to produce new repair methods for high-cycle oil recovery equipment.

**Monitoring bridge health**: Expertise from the center's airplane safety research was applied to monitor the health of bridges.

**Robotic inspection of wind blades**: The center's expertise in nondestructive inspection was applied to develop a robotic inspection system to monitor the integrity of the blades on wind turbines.

Aircraft designs for tomorrow: In its work to deploy advanced aircraft maintenance technology and new materials, the AANC teamed with over 300 companies and government organizations and conducted Strategic Partnership Projects in ten countries.

## 'Vast expertise' at Sandia-AANC

"I never could have imagined back in 1990 that this program would end up spanning 30 years and contribute so much to commercial aviation safety," said Dave Galella, FAA program manager. "It was incredibly comforting to know that whenever a new airworthiness challenge arose, I could pick up the phone and have access to the vast expertise that resided at the Sandia-AANC."

During its time at Sandia, the center has received dozens of patents, won nine "Better Way" awards from the Airlines for America and FAA, produced more than 500 publications and formal procedures and helped develop regulatory measures to advance the aviation, aerospace, oil and gas, renewable energy, automotive and nuclear energy industries. The team worked on multiple international committees to produce worldwide standards for aircraft maintenance.

**737 AIRCRAFT TESTBED** — A 737-200 aircraft, circa 1968, which experienced 50,000 flight cycles in its lifetime and then served as a full-scale testbed for numerous inspection development programs at the AANC hangar facility that Sandia operated at the Albuquerque International Sunport.

"The AANC has been a highly successful collaboration offering the opportunity to develop new technologies for aviation assurance that further enabled structural health monitoring for our core NNSA physical security program and other programs," said Sandia director Gary Laughlin. "Dennis Roach has been a central figure and leader both technically and programmatically in the program from its inception."

All of the assets acquired during the program, including nondestructive inspection equipment, test specimens, custom tools, new inventions and an aviation document library were loaded into trucks in late April and transferred to a new hangar at Wichita State University. Most Sandia researchers working at the center have retired or transferred to other projects at Sandia, while Dennis says the transition lines up with his planned retirement and movement into aviation consulting.

Dennis estimates that more than 100 Sandia researchers contributed to projects at the center. The program brought in $120 million in funding over 30 years and led to an additional $30 million from industry partnerships.

## Mileposts

Matthew Brown 30

Ron Farmer 30

Sharon Evans 20

Deanna Montoya 20

Robert Mills 15

# Hruby and Truman Fellows take time out to chat

## *Bette Webster, Nils Otterstrom and Aaron Sharpe talk about their research careers and Sandia*

*By* **Amy L. Treece**

A trio of postdoctoral fellows joined Sandia last September to conduct their research in support of the Labs' national-security mission.

Elizabeth "Bette" Webster was awarded a Jill Hruby Fellowship, named for the first woman to direct a U.S. national security laboratory and President Biden's nominee as the next NNSA administrator. Nils Otterstrom and Aaron Sharpe received Harry S. Truman Fellowships and are conducting their work through the Laboratory Directed Research and Development program.

Lab News spoke to each fellow about the work they plan to conduct over the next three years.

### Elizabeth "Bette" Webster:

**On the frontlines of the virologic war**

While at Stanford University, Bette focused her doctoral research on viral membrane platforms and host-pathogen interactions. She is continuing her work in biotechnology and bioengineering.

**Lab News:** Did the COVID-19 pandemic amplify the need for any specific aspect of your research?

**Bette Webster:** The pandemic highlighted the need to better understand emerging viral threats. My fellowship research develops model membrane platforms to characterize enveloped virus entry and membrane-based delivery systems. Fundamental studies help us gain a better understanding of membrane entry mechanisms, which then can be used in technologies to address future viral threats.

**LN:** Viruses and bacteria are difficult to treat because they reside in intracellular membrane compartments. How does developing membrane platforms assist you in examining host-pathogen interactions?

**BW**: To successfully infect a host, an enveloped virus must fuse its membrane with that of the cell. This process of membrane fusion is highly conserved, presenting a unique target for combating viral threats. By using model membrane platforms, I can precisely examine how specific factors, e.g., lipid composition and changing pH, play a role in membrane fusion, and also build complexity into the system, e.g., isolating host membrane protein, while limiting the number of variables involved. It's critical to understand how each piece fits together, and this approach allows me to be very controlled and examine how different membrane factors play a role in virus entry.

**LN:** How would your work creating biological testing procedures align with nanoparticle delivery and detection platforms used in vaccines?

**BW:** Nanoparticles help navigate various biological barriers that are heterogeneous across patient populations and diseases. Some of the current vaccines for COVID-19 are lipid nanoparticle technologies which demonstrates their utility as a delivery mechanism. My membrane platforms could help identify a fundamental approach for characterizing these systems and improving lipid-based delivery systems, which could lead to development of novel nanoparticle applications.

**LN:** Stanford encourages creative thinking, interdisciplinary collaboration and high-stakes, high-reward research. Sandia's LDRD Mission Campaigns and Grand Challenges operate in a similar fashion. How did your PhD experience prepare you for larger, cooperative research projects?

**BW:** At Stanford, I was part of the Chemistry, Engineering, and Medicine for Human Health (ChEM-H) Program. While my doctorate is in Chemistry, my research intersects many areas including virology, surface science and membrane biophysics. The ChEM-H Program was instrumental in developing collaborative networks, troubleshooting technical difficulties in the lab and developing new ways of asking questions. That interdisciplinary environment broadened my knowledge beyond my own field and challenged me to clearly communicate with others whose specialties differ from my own.

**VIRAL WARRIOR** — Chemist Bette Webster joined Sandia as a Hruby Fellow last September. **Photo by Randy Wong**

**LN:** What motivated you to pursue a career in research?

**BW:** My scientific mentors helped me understand that the impact you have on others can be just as important as the scientific findings. At the University of San Diego, my undergraduate research mentor, Prof. Lauren Benz, provided

scientific training as well as subtle demonstrations of inclusive teaching and mentorship, practices I continued to refine in graduate school. A career in research allows me to answer interesting scientific questions while creating an inclusive culture and mentoring future generations.

**LN:** How do opportunities like the Jill Hruby Fellowship motivate early career researchers?

**BW:** The Jill Hruby Fellowship provides me with the independence to pursue my own ideas and research while gaining valuable insight into Sandia's structure and research portfolio, which facilitates my leadership development. Being able to contribute toward Sandia's larger mission is truly exciting.

## Nils Otterstrom:

**Lighting the way to a quantum future through photonics**

Nils, an applied physicist who completed his doctorate at Yale, works in photonic microsystems. His focus is on using nonlinear optical processes in integrated photonics for quantum networking, computing and sensing applications.

**LN:** Quantum computing is a field with seemingly boundless applications. How would your work in this area be a potential game changer?

**NO:** There are a variety of promising candidate physical systems for quantum computing, including trapped ions, superconducting qubits, photonics and defect centers in crystals. Sandia is a leader in many of these areas. Each one has its own relative advantages and disadvantages. In this context, a tantalizing goal is to create hybrid quantum systems that can synergistically combine the strengths of these disparate platforms and technologies.

My Truman research aims to leverage the unique properties of light to interface and network disparate quantum systems and technologies. Central to this work is the concept of transduction — converting qubits from one state to another. If we're successful, we'll be able to leverage and combine the advantages of different quantum systems and necessary technologies that otherwise would be very challenging to bring together.

**PHOTONIC FELLOW** — Applied physicist Nils Otterstrom joined Sandia as a Truman Fellow last September. **Photo by Randy Montoya**

**LN:** The introduction of a Science magazine article where you were first author noted, "Silicon is the workhorse of the semiconductor electronics industry." What experiences drove your interest in silicon?

**NO:** I began my research career as an undergrad working in an atomic physics lab. The experiments were physically impressive and required an expansive and complex arrangement of optics, lasers and vacuum chambers. As I worked on different optical systems, I became enamored with integrated photonics, where you can, in principle, miniaturize large optical systems, which otherwise could occupy a good part of a large optics table, into compact silicon chips. To do this, we use standard, highly scalable microelectronic fabrication techniques to make tiny silicon photonic waveguides, or wires, that convey light around the chip. In my graduate research at Yale with Peter Rakich, a former Sandian, we harnessed radically enhanced interactions between light and gigahertz-sound waves to make new types of optomechanical-based lasers and optical amplifiers. One of many exciting facets of research in this area is that advances can readily be adapted to scalable technologies since we're using standard complementary metal-oxide-semiconductor processes.

**LN:** What outcomes are you hoping for during your time at the Labs?

**NO:** I had the opportunity to collaborate with Sandia's microsystems group during my PhD work, and I was impressed by the scope and quality of research in this area. Sandia is a true leader in this field thanks to the Microsystems Engineering Science and Applications program's advanced foundry-scale manufacturing capabilities and expert scientists and engineers. I hope that my unique research trajectory will have a profound impact on the field and important mission applications.

**LN:** Sandia's LDRD program has roots in discovery science and mission application. How does this hybrid approach incentivize early career researchers?

**NO:** Young researchers are interested in having real impact. At Sandia, we have the chance not only to influence the academic community, but also to make a difference in real-world national security applications. The work here is meaningful on multiple levels.

## Aaron Sharpe:

**Drawn toward superlattices and quantum magnetism**

Aaron graduated from Rice University and obtained his doctorate in applied

**MAGNETIC MAN** — Applied physicist Aaron Sharpe joined Sandia as a Truman Fellow last September. **Photo by Randy Wong**

physics from Stanford. He joined Sandia to investigate properties of twisted bilayer graphene and to establish its viability as a cryogenic memory element for classical cryogenic computers.

**LN:** DOE recently announced they want to fund research toward the development of a quantum internet. Does your discovery in ferromagnetic behavior and work in emergent quantum magnetism and cryogenic spin-memory have implications for such an application?

**AS:** A particular challenge for a quantum internet based around quantum devices is that they need to be kept extremely cold to function. The prominent technologies for solid state quantum computers are superconducting and semiconductor spin qubits, both of which will likely need to be cooled to below 100 millikelvin in an ultralow temperature cryostat. It's likely a powerful classical computer will need to interface with the quantum computer and be mounted within the cryostat, so a classical computer will need to be designed to operate at ultralow-temperatures. Very little research has been done into meeting the efficiency requirements for cryogenic memory, and that's what makes the discovery of ferromagnetism in twisted bilayer graphene such a pleasant surprise. Discovering that graphene, a material composed entirely of carbon, can become magnetic and that the magnetism can be controlled electrically makes it a strong candidate for an extremely low-power cryogenic memory.

**LN:** How could graphene superlattices be leveraged in quantum systems?

**AS:** Superlattices are basically the same idea as the strange optical effect you can see when driving under an overpass with chain-link fences on both sides, or why you can't wear a striped shirt on television. When you have two similar patterns overlapping with a slight shift or rotation — either the two fences or the shirt and pixels of your TV display — you form a moiré pattern: an interference pattern of a much larger length scale. Typically, electrons in graphene travel about and don't care about each other at all. But by stacking at a very particular relative angle, the electrons now "feel" each other and behave cooperatively to minimize the total energy of the system. This was the key leap leading physicists to discover that graphene can become both a superconductor and a ferromagnet. This tunable platform will hopefully lead to key insights in developing novel quantum devices.

**LN:** What impact do design competitions such as the DREAM program in which you've been involved have on students?

**AS:** DREAM, a volunteer-based mentorship program, strives to increase the number of underrepresented minority students earning undergraduate degrees in STEM through high school design competitions. Sandia's Brent Houchens has served as the program's adviser since its founding in 2006. The DREAM competitions get students talking to the mentors, but once engaged in a small team setting, they talk to the mentors about big questions such as college. Over four years, I mentored many students, and it was rewarding to walk into a huge high school and have those students yell out to me.

**LN:** What is it about Sandia's LDRD program that motivates early career researchers to pursue work at a national laboratory?

**AS:** As a researcher who performs fundamental research, the national laboratories provide the security of assured funding, which allows researchers to go after difficult, high upside questions. My main concern was getting stuck in my own little research island, but there is also a ton of flexibility to seek out other research opportunities at Sandia.

# Rockets, hurricanes and Kauai enchiladas

## *Range chief reflects on 41-year commute to tropical paradise*

*By* **Jennifer Sawayda**

Many assume working at the Kauai Test Facility to be a dream job, working in the tropical paradise island of Kauai, Hawaii, in the U.S. Navy Pacific Missile Range Facility.

Steven Lautenschleger, Sandia's manager of KTF and Remote Ranges, would agree. As Steven prepared to retire from Sandia, he reflected on his time at KTF.

"The challenge of preparing for flight tests, the complexity of the systems, and the incredible folks who support them makes me feel like I've had the best job available at Sandia," Steven said.

Sandia is the only Federally Funded Research and Development Center to operate a full-scale missile flight test range. Steven was hired at Sandia in 1980 and began in the

**ROCKING THE ROCKET** — Under Steven Lautenschleger's watchful eye, the Kauai Test Facility team moves about 15 tons of explosives into position for a flight test. Coordination, planning, procedures, dry runs and pathfinder exercises all precede the launches, Steven said. **Photo by Diana Helgesen**

**FIRING THE BOOSTER** — This static fire test of a Polaris missile booster motor was performed at the Naval Air Weapons Station China Lake in California in the early 1990s. Working with the payload, rocket and range departments required Steven to travel to activities at a wide variety of locations. **Photo courtesy of Aerojet General, Sacramento, California**

**NOT ALL WORK, ALL THE TIME** — Steven Lautenschleger and daughter Julianna on the beach 25 years ago. Sandia groups would get together at the Navy's all-hands club Fridays after work at KTF to share a pizza and play volleyball. Friends and family would visit the Sandia crew during longer deployments. **Photo by Diana Helgesen**

design definition group, working on payloads for rockets. During his 41 years at the Labs, his career has been intertwined with KTF.

"In 1983, Reagan gave his Star Wars speech, which started missile defense work in a major way," Steven said.

He started working on rockets at KTF in 1990 and moved to the island as site manager in 1996. After five years, he moved back to Albuquerque and took on other military support roles with work on aerospace and rocket programs. In 2011 he became the manager of KTF and Remote Ranges.

Since the start of his career, Steven has participated in or supported more than 80 flight tests, 56 of them at KTF. A typical launch takes about six or seven weeks of preparation, although they can go longer. KTF launches four to six rockets a year.

Over the decades Steven has seen KTF diversify, although its primary mission as a missile launching facility has remained unchanged.

"We've primarily remained in missile defense, but we've seen a lot of diversification over the years in our customer base," Steven said. "We've become much more engaged with hypersonics, rapid prototyping for NNSA, even a light satellite launch."

KTF's strategic location next to a broad ocean area, combined with the pleasant weather of Hawaii, make it ideal for flight activities. However, working on a tropical island has its challenges, including a long hurricane season that can delay flights. Steven recalls visiting Kauai after Hurricane Iniki devastated the island in the early 1990s.

"Only 15 percent of the island had power," he said. "Surprisingly, when we went out to assess the damage to KTF, we found that the facilities, including the range systems and the rocket vehicle itself, survived almost intact."

Sometimes weather combines with vehicle anomalies to waylay even the most carefully considered plans. In October 2014 the Missile Defense Agency set a goal of four launches within three weeks, but problems arose almost immediately.

"The first vehicle on the pad had an anomaly so we de-stacked for two weeks for repairs, restacked and launched one day ahead of Hurricane Anna making landfall," Steven said.

**MANY HANDS MAKE THE LAUNCH** — KTF personnel watch a launch from the Launch Operations Building. The Kauai Test Facility partners with organizations across the Labs to execute its mission. A variety of sponsors as well as numerous commercial aerospace entities round out the launch team. **Photo by Mike Bejarano**

**NIGHT FLIGHT** — A rocket takes off from KTF during a night launch in May 2016. Steven Lautenschleger rarely sees launches in real time, instead monitoring them from inside the Launch Control Building. **Photo by Mike Bejarano**

**CAMPOUT AT MAJOR'S BAY** — One of the largest beaches on Kauai is on Sandia's host base, the Pacific Missile Range Facility. Prior to the 9/11 attacks, Steven and other Sandians could drive right onto the beach and camp. **Photo by Sharon Lautenschleger**

The second flight also was postponed, followed by anomalies on one of the launchers and with the third vehicle's flight test. This required the crew to remove the fourth vehicle and launch it from a different pad within three days.

"Three weeks turned into six weeks," Steven said. "During that time, my test director was able to spend quality time discussing anomalies with the three-star director of MDA who was at the Pacific Missile Range Facility for the test."

Being KTF manager requires flexibility and quick problem solving, as such delays can be costly. For instance, one month after becoming range manager, while returning home from vacation, Steven learned about a small fire in the Launch Operations Building. The fire caused massive smoke and water damage.

"Although we hired a remediation company to help, it was up to our staff to completely gut the ground station and all launch control systems, as well as clean, reinstall and certify for a launch three months later," he said. "It took incredible teamwork to pull that off."

Steven recalled a time when a leak in a support building roof damaged equipment required for launch. Personnel hand carried replacement parts from the mainland and met a chartered helicopter that delivered them to KTF. They were installed and verified minutes before the Go/No-Go meeting, where the facility was announced as "Green" for launch.

Steven lives in Albuquerque, and travels to Kauai about once a month.

"This amount of extended travel requires commitment from your family as well," he said. "My wife and daughter have supported me on this ride from day one." His wife accompanies him sometimes, bringing authentic New Mexico chile to Hawaii. "We always take chile out there when we visit, and a couple of the local staff have gotten good at making green chile chicken enchiladas," Steven said.

Despite his love for his job, Steven admits sacrifices are required, including frequent travel, long hours at the range and a mound of environmental considerations as Hawaii is home to endangered fauna. In the past year, the COVID-19 pandemic introduced new challenges that complicated Steven's final year at Sandia.

"We couldn't travel to KTF on our normal support schedule, and when we did travel out there, it was for longer stints of time due to the need to quarantine," Steven said.

In spite of these challenges, Steven views himself lucky to have been a part of life at the range for so long.

"Not only was the work exciting," Steven says, "But getting to know the people and being immersed in a different culture and lifestyle in such a beautiful environment has made this a fascinating career."

**WATCHING THE SKY** — The sun sets at Kauai Test Facility.

**Photos courtesy of Steven Lautenschleger**


**FOND FAREWELL** — Steven Lautenschleger leaves KTF for retirement. During his nearly 41 years at Sandia, his career has been intertwined with KTF the entire time.